

**THE SOLBERG COMPANY**

**TECHNOLOGY TITLE  
RE-HEALING FOAM – COMPLIANCE TO THE 2015 USEPA STEWARDSHIP PROGRAM AND  
BEYOND**

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## TECHNOLOGY

### RE-HEALING™ Foam – Compliance to the 2015 USEPA Stewardship Program and Beyond

The nominated technology is neither small business nor academic. It was developed by The Solberg Company independent of outside funding.

This technology complies with the USEPA Focus Area 3: The Design of Greener Chemicals.

The most recent product milestone was completion of the Underwriters Laboratories (UL) and Factory Mutual (FM) product certifications of non-fluorinated Class B flammable liquid firefighting foams for industrial applications, completed in the Spring of 2014. This allows for commercial introduction into the United States.

The US component of this technology is the unique, patented chemistry, which was developed, tested, listed, approved, and manufactured in the Solberg factory located in Green Bay, Wisconsin.

## ABSTRACT

RE-HEALING™ Foam (RF) was developed to address a significant environmental issue of all synthetic firefighting foam concentrates, which was initially identified in 2001. Firefighting foam was based on the use of fluorinated surfactants, which were effective as a key component of these foam concentrates, but was identified by the USEPA as Persistent, Bio-accumulative, and Toxic. In response to this concern, the USEPA issued its 2010 and 2015 Voluntary Stewardship Program, working with the industry to eliminate long-chain fluorosurfactants from firefighting foam. At Solberg, we considered this change to short chain surfactants as short sighted and short-term thinking, and rather chose to solve the problem by eliminating these persistent pollutants from our firefighting foams. Solberg has developed and commercially launched a line of organohalogen free foam concentrates.

While the USEPA Voluntary Stewardship Program addresses long chain perfluorinated chemicals, it does not address the firefighting performance of foam concentrates based on the newer generation of short-chain perfluorinated chemicals, which must be used at greater levels to achieve equal fire extinguishing performance on fires. This leads to greater amounts of persistent chemicals introduced into the environment during firefighting.

At Solberg, we elected to eliminate all organohalogens from our foam products due to their persistence. As a result of several years of research and live product use on fires, we have developed products that are equal, and in many cases superior, to their fluorinated counterparts. We have achieved full regulatory compliance to existing fire protection standards, while eliminating persistent chemistry.

Today, Solberg RE-HEALING Foam is the World's most effective firefighting foam concentrate for flame knockdown, fire control, extinguishment, and burn-back resistance. Control,

extinguishing time, and burn-back resistance are paramount to the safety of firefighters everywhere, and RE-HEALING foam is superior to all other foam concentrates.

## THE PROBLEM

In 2006 the USEPA established a voluntary Stewardship program, the intent of which was to reduce the impact of long chained fluorosurfactants and their associated degradation products in the environment. All producers of fluorosurfactants signed on to this program with the intent of eliminating C<sub>8</sub> and longer fluoro-chemistry from the market. The driving purpose behind the removal of long-chained-fluorosurfactants was the persistence of the molecule in the environment, their bio-accumulative properties and the associated toxicity of their degradation products. These three characteristics of Persistence, Bioaccumulation, and Toxicity, PBT, have resulted in the appearance of fluorosurfactant chemical backbones in populations that were not directly exposed to the primary chemical but rather through indirect exposure by chemical migration within the ecosystem. The persistence of these chemicals has created a presence in natural waters and the food chain that affects all species and will be present for many centuries.

The conventional business model addresses the problem by working within the confines of what it knows. The logical solution would be to shorten the chain length of the fluorochemical thereby changing its characteristics to make it less persistent, bio-accumulative or toxic. While the toxicity or bio-accumulation of a molecule can be changed by manipulation of chain length, persistence cannot be altered. A fluoro-molecule will not fully degrade to elemental materials regardless of the starting chain length of the molecule. As such it will always be present in the environment as a short-chained fluorochemical.

While the Voluntary Stewardship Program addresses the Persistence, Bioaccumulation, and Toxicity (PBT) of long chain perfluorinated chemicals, firefighting performance of foam concentrates cannot be sacrificed in the change to short-chain perfluorinated chemicals. Fire performance is measured against known international standards. In the U.S. the recognized standard is Underwriter Laboratories, UL-162, The Standard for Foam Hardware and Liquid Concentrates. This standard describes fire test conditions, acceptable performance and the requirements for matching fire performance to foam hardware. Fire performance as both freshwater and sea water foam solution is measured using two parameters, extinguishment and 20% burn-back. Extinguishment is achieved when the test fuel is extinguished within the allotted foam application period typically three or five minutes, depending upon the fuel type, hydrocarbon (water immiscible) or polar solvent (water miscible), with the longer application time used for polar solvent fuels. Upon successful extinguishment the foam blanket rests undisturbed for a period of time equal to three times the application time, nine or fifteen minutes. At the end of this period a burn-back test is conducted to determine the integrity of the foam blanket. A one-square foot round sleeve is inserted into the blanket, the foam inside the sleeve is removed and the fuel lighted. The sleeve is allowed to burn for one minute and is then removed the open area is allowed to burn for five minutes. The maximum area of involvement of the fuel surface is 20% at the end of the five minute period. A self-extinguishment of area less than 20% constitutes acceptable performance.

The data in Table 1 indicates the increase in fluorine level associated with short-chained C<sub>6</sub> fluorosurfactant added above the level of a baseline C<sub>8</sub> fluorosurfactant product. To achieve similar acceptable fire performance to the UL-162 standard it required almost 40% more C<sub>6</sub> fluorine. While the C<sub>6</sub> homologues may have reduced toxicity and bioaccumulation associated with fluorochemicals, the amount of persistent fluorochemical introduced into the environment will be increased significantly.

**TABLE 1**

<b>Composition</b>	<b>90% Control Time</b>	<b>Extinguishment</b>	<b>Burn Back</b>
Base C <sub>8</sub> Chemistry	0:31	1:42	8% @ 5:00 FW
	0:33	1:50	10% @ 5:00 SW
Base C <sub>6</sub> Chemistry	0:37	3:36	Not Done
+1.4% C <sub>6</sub> Chemistry	0:33	2:15	20% @ 2:00
+11.4% C <sub>6</sub> Chemistry	0:36	1:48	20% @ 3:45
+32.9% C <sub>6</sub> Chemistry	0:37	1:30	S.E. @ 3:00 FW
	0:29	1:25	20% @ 4:00 SW
+39.7% C <sub>6</sub> Chemistry	0:29	2:00	6% @ 5:00 FW
	0:48	2:07	16% @ 5:00 SW

## THE CHEMISTRY

RE-HEALING Foam concentrates are a blend of hydrocarbon surfactant(s), water, solvent, complex carbohydrates, a preservative and a corrosion inhibitor. Concentrates are formulated to be used as 1%, 3%, or 6% products, used for extinguishing Class B hydrocarbon fuels. These fuels are described in the industry as water immiscible and are represented by such materials as gasoline, jet fuel and diesel fuel. A second class of fuels are the water miscible types, these include, but are not limited to, products like ethanol, methanol, and acetone, common solvents used in the paints and coating industry as well as in transportation. The foam concentrates used to suppress fires with these solvents are blended from the same ingredients, with their use levels modified to enhance performance. The presence of complex carbohydrates gives the foam significantly more capacity to absorb heat than fluorine containing foam. This improves the extinguishing property of RE-HEALING foam and adds to the burn back capacity. The renewable hydrocarbons used in RE-HEALING foam concentrates are the same products used in the health care industry, which results in a cleaner product. The use of these products results in a product that has very favorable hygiene and environmental properties. Table 2 lists the results of testing conducted by the German Hygiene institute on RE-HEALING RF 3 foam concentrate. The raw materials found in RF3 are used throughout the RE-HEALING line.

**TABLE 2**

TEST		RESULT	
		RF3 Concentrate	3% RF3 in Fresh water
			3% Solution
Bacterial toxicity		0.00565	0.188
Fish toxicity	LC 50	23	767
Daphnia toxicity	EC 50	50	1667
Algae toxicity	EC 50	150	5000
Oral mammal toxicity	(limit concentration of 2000)	> 2000	> 2000
Biodegradability	COD	560000	560000
	BOD 5 day's	240000	240000
	Biodegradability 5 day's	42.9	42.9
	Biodegradability 28 day's	93.2	93.2
Biological Soil testing			
Inhibition of Germination of plants	EC50 Barley	1000	> 10000
	EC 50 cress	6000	> 10000
	EC 50 radish	> 10000	> 10000
Inhibition of Growth of plants	EC50 Barley	300	> 10000
	EC 50 cress	800	> 10000
	EC 50 radish	500	> 10000
Toxicity for Earthworms	EC 50	5500	> 10000
Recommendations on Soil	No significant effect	100	3333
	NOEC	< 100	< 3300
Skin irritation	erythema and scab	1	NA
	formation of edema	0	NA
	According to the hazardous substance law	NON	NON
Eye irritation	cornea	0	NA
	iris	1	NA
	conjunctiva	1	NA
	According to the hazardous substance law	NON	NON

RE-HEALING foam concentrates have completed the listing process with Underwriters Laboratories and the systems approval process with Factory Mutual and have demonstrated equal or better performance when compared against C<sub>6</sub> fluorochemical foams. Extinguishment times are on par with traditional fluorine containing foams while RE-HEALING foams consistently exceed in burn back resistance. From Table 2 it can be seen that toxicity, persistence and bioaccumulation are superior for the non-fluorinated RE-HEALING foam. RE-HEALING foam achieved 93% degradation in 28 days, and complete reduction by day 42.

RE-HEALING foam has been granted numerous patents around the World, including the United States (patent number 11/885,495, published 1/14/2009), Norway, Canada, Mexico, China, the European Union, Macau, Australia, Hong Kong, Israel, South Korea, and Taiwan.

### **REALIZED OR POTENTIAL BENEFITS AND DRAWBACKS**

The benefits to the use of RE-HEALING foam concentrate are many, and include:

- Customers in high hazard, high risk businesses, such as petrochemical, oil, and gas, can purchase foam concentrates that are highly effective, yet leave no environmental legacy, to achieve their organizations environmental goals.
- The product uses no PBT chemistry in its formulations.
- The product is manufactured in our Green Bay, Wisconsin facility, which has been designed with a “Green” responsibility to the environment. The buildings are LEED certified.
- Our second manufacturing operation, in Bergen Norway, has been awarded an Eco-Lighthouse Certification (Environmental Sustainable Status).
- The product is not sold at a price premium to the current PBT technology, so the customer pays no premium to practice environmental responsibility.
- The RE-HEALING foam concentrates are easy to retrofit into existing foam systems, as a replacement to the PBT chemistry used by others. No specialized equipment is required.
- RE-HEALING foam is available in all product types to handle the full range of flammable and combustible liquids.
- It is a challenge for us to determine drawbacks to this technology. The only reasonable drawback is the time for market knowledge and acceptance for full commercial acceptance.

### **IMPACT & RESULTS**

While this technology is new to the marketplace, and will take time for full market acceptance, the change in the market is already starting. For instance, in Norway, Statoil, one of the World’s largest oil and gas producing companies, has now selected RE-HEALING foam for retrofit on all of its offshore platforms, and when complete they will retrofit their on-shore operations. They have made the decision to remove the PBT foams from their operations and replace it with this new technology. Several other oil companies, having been made aware of this, are now starting this process as well.

In the US, the market acceptance is now underway. We have added sales staff throughout the country, which has targeted the specifying engineering community, contractors, and end users in the oil and gas industry. As a result we have conducted numerous product demonstrations

to prove the performance to a fairly skeptical audience; for 50 years these users have been told that only the PBT chemistry can perform in these very challenging fires, and the demonstrations are critical to convince the industry to change. The demonstrations have been filmed for viewing, and can be seen at <http://www.rehealingfoam.com/>.

The last significant innovation in firefighting foam came in the mid-1960's with the introduction of synthetic foam concentrates, which we have referred to as the PBT chemistry. These "synthetic based" foam concentrates replaced 1930's technology protein (hydrolyzed animal rendering based) foam concentrates and used fluorosurfactants (i.e. fluorine) as the main product ingredient. It is our desire to lead a revolutionary technology change in the fire protection industry with the introduction of fluorine-free foam in much the same manner as synthetic foams replaced protein based foams back in the 1960's.

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### **CURRENT AND PLANNED COMMERCIALIZATION**

As a result of the commercialization of this technology, we have determined that the change to this technology should be made as simple as possible for our customers. So among several marketing and sales promotions, we are offering two programs that are unique to RE-HEALING foam, and are not offered by any other foam manufacturer in the World. These are:

- **The RE-HEALING Foam Environmental Warranty.** At Solberg, we decided that more than just talking about environmental benefits was required to launch this product. For purchasers of RE-HEALING foam, we offer the customer an unconditional 20 year Environmental Warranty, that if our technology is regulated anywhere in the World where the customer operates, we will remove and replace the foam concentrate with whatever new product complies with the new environmental regulation, even if the replacement foam is not offered by Solberg. So rather than talking about the environment, we live it every day through our products.
- **The RE-HEALING Foam System Upgrade Program.** For customers that would choose to upgrade their current foam systems from the PBT chemistry to RE-HEALING foam, but are concerned about the loss of the system's approval from either UL or their insurance Company, we created a Retrofit Program whereby the customer purchases the RE-HEALING foam at market price, and for free, Solberg adds the necessary hardware components to the system so that no third party approval is affected. This removes all regulatory approval issues for the customer, so that they can remove PBT chemistry from their operations, convert to the environmental solution, and maintain their regulatory approvals at no added cost.

No other foam company in the World offers either of these programs for customers. Solberg stands behind its environmental products in the market as no other company will.

Solberg's facility in Green Bay has the capability to produce several thousand gallons per day of foam concentrate, which handles the current and planned demands for the product in the Americas. Our office and warehousing facilities are LEED certified, and have zero discharges to the environment. The manufacturing process is computer controlled for exact product quality control and packaging, and the building is sealed to avoid any product ingredients from migrating out of the building. We also constructed a state of the art fire test facility, the largest privately owned fire test facility in the country, to support continued product development of this technology for our customers. The fire test facility, while used for the burning and fire testing of flammable and combustible liquids, is also designed to have no environmental impact, as all products of combustion are contained within the facility, and processed through our multi-stage wet and HEPA filter dry scrubbing system, so that the air discharged from our test house is actually cleaner than the incoming air used for combustion.

It is this commitment to the environment for our products, our facilities, and our test building that makes Solberg unique in the global foam market. No other foam company in the World operates in LEED certified facilities, uses scrubbers to eliminate air pollution during testing, and offers product environmental warranties and retrofit programs to its customers, on a global basis.